Remarks

By the foregoing amendment, claims 1-20 are amended. Applicants have also amended the specification to correct a wording error. No new matter was added by this amendment, as all amended matter was previously illustrated and/or described in the drawings, specification, and/or claims of the application. Entry of the amendment and favorable consideration thereof is earnestly requested.

Amendments to the Specification

Presented above are replacement paragraphs [0011], [0027], and [0029]. Each of these paragraphs originally used the term “vertical height” to describe the size of the inlet zone out of which the gases flow into the process chamber. The term “vertical height” could be confusing and was the result of a translation into English from German. Applicants have corrected this potentially confusing term by replacing “height” with the word “size.” This correction was also made in the claims. No new matter has been added.

Claim Rejections – 35 U.S.C. § 102/103

The Examiner rejected claims 1, 3, 6, 9, and 10 under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 6,218,212 to Saito et al. (“Saito”). Claims 2, 16, and 20 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Saito in view of DE 10247921 to Kaeppler (“Kaeppler”). Applicants request reconsideration of these rejections in light of the foregoing amendments and the following remarks.

Claim 1, as amended, recites a device for depositing crystalline layers on substrates in a process chamber. The device includes a gas inlet member disposed at substantially the center of the process chamber, which forms gas inlet zones out of which gaseous starting materials are introduced into the process chamber. The gas inlet zones comprise: a bottom gas inlet zone neighboring the floor of the process chamber; a top gas inlet zone neighboring the ceiling of the process chamber; and a middle gas inlet zone between the top and bottom gas inlet zones. A supply of a hydride is connected to the bottom and the top gas inlet zones and a supply of a metalorganic compound is connected to the middle gas inlet zone. At least one substrate carrier is arranged around the gas inlet member and is rotationally driven around its axis. With this device, the hydride and metalorganic starting materials form a stream of gas that is homogenized and at least partially pre-decomposes in an inlet zone directly adjacent to the gas inlet member. The decomposition products of the starting materials are then deposited on the substrates in a growing zone adjacent to the inlet zone.

The related method of claim 2, as amended, includes the steps of: positioning a gas inlet member at substantially the center of a process chamber; arranging one or more substrates in a rotationally symmetric manner around the gas inlet member; rotating each substrate; introducing a first gaseous starting material through a bottom gas inlet zone neighboring the floor of the process chamber and a top gas inlet zone neighboring the ceiling of the process chamber; and introducing a second gaseous starting material through a middle gas inlet zone between the bottom gas inlet zone and the top

gas inlet zone. The first starting material is a hydride and the second starting material is a metalorganic compound. Again, the starting materials flow in a horizontal direction together with a carrier gas through the process chamber, the stream of gas being homogenized and the starting materials at least partially pre-decomposed in an inlet zone directly adjacent the gas inlet member. The decomposition products of the starting materials are deposited on the substrates in a growing zone adjacent to the inlet zone, while the stream of gas is steadily depleted. The steps of introducing the starting materials are performed in order to reduce the horizontal extent of the inlet zone.

The amendments to claims 1 and 2 are primarily to re-order the elements of the claims in order to improve their clarity. However, some elements have been added. Support for the element that the gas inlet member is disposed at substantially the center of the process chamber is also present in at least claim 10. Support for the element of at least one substrate carrier arranged around the gas inlet member, being rotationally driven around its axis is present in at least claim 12. No new matter has been added to the claims.

Thus, the present invention relates to a process and device for depositing layers on substrates using the starting materials of a hydride and a metalorganic compound. The claimed device and method, therefore, relate to MOCVD processes and reactors. As recited in the claims, the hydride enters through the bottom and top gas inlet zones near the floor and the ceiling, respectively, of the process chamber, while the metalorganic compound enters through the middle gas inlet zone provided between the hydride inlet zones.

The starting materials decompose in the inlet zone (EZ in FIG. 2). FIG. 2 shows the growth rate versus the distance from the gas inlet member. The maximum of the growth rate (reference numeral 10 in FIG. 2) marks the beginning of the growing zone (GZ in FIG. 2). The process chamber has a rotational symmetry with respect to the center of the gas inlet member. To increase the efficiency of the MOCVD reactor it is necessary to keep the radial distance of the inlet zone as small as possible and to keep the radial distance of the growing zone as large as possible. To increase the overall diameter of the process chamber, it is necessary to alter the total flux of carrier gas and starting materials through the process chamber. Using a conventional MOCVD-reactor as disclosed in the prior art (see DE 100 43601 A1 (US 6,972,050 B2) or DE 10057134 A1 (US 6,147,718 B2)) this change in the flow parameters shifts the maximum of the growth rate to a higher radial distance from the center of the gas inlet member. The growth rate curve is shown by the dot and dashed line in FIG. 2. The solid line shown in FIG. 2 represents the growth rate curve when the method/device of the present invention is employed.

There is a second feature that is very important for quality growth of III-V-layers in a MOCVD process. A homogeneous distribution, and thus, a uniform thickness of the layer, across the entire substrate is required. That means the growth rate in the growing zone must be constant with respect to the radial distance from the center of the process chamber. Due to the depletion of the gas phase, which cannot be avoided, the growth rate decreases with the distance in flow direction. These depletion effects are compensated for by rotating the substrates to optimize the homogeneity of the layer

thickness, as recited in the pending claims. The depletion curves, therefore, should be as close to linear as possible.

In the processes of the prior art, which are disclosed in the above mentioned documents, the V-component—the hydride—is injected directly above the floor of the process chamber and the metalorganic component is injected at a vertical distance to the floor that is near the ceiling of the process chamber. It has been found that injecting an additional amount of the hydride next to the ceiling (*i.e.*, above the metalorganic component) influences not only the position of the maximum of the growth rate, but also the shape of the depletion curve.

The Claims are Patentable over the Cited References

None of the cited references disclose the injection of a hydride into a process chamber via a top and bottom gas inlet zone and the injection of a metalorganic compound via a middle gas inlet zone. None of the cited references disclose this arrangement in combination with a gas inlet member located at the center of a process chamber with at least one rotatable substrate around the gas inlet member.

Saito does not disclose the use of both a hydride and a metalorganic compound as starting materials. Saito discloses the use of DMCd and DIPTe as metalorganic starting material and gaseous Hg to form CdTe and HgTe. CdTe and HgTe have different formation energies as shown in figure 2 of Saito. Separating the injection of DMCd and DIPTe leads to a uniform formation of a ternary compound HgCdTe. To separate the two metal organic starting materials, Saito discloses the use of a partition plate.

In figure 9, Saito discloses an arrangement for growing quaternary layers with an additional injection of DEZn. DEZn is injected between the injection zones for DMCd and DIPTe. The reason for separating the injection of the metalorganic components is not to increase the efficiency of the growth process or to linearize the depletion curve (as in the present invention), but, rather, to add the metalorganic components in different horizontal distances upstream of the substrate into the process chamber. To accomplish this, the partition plates shown in figure 9 have different horizontal lengths.

Saito does not disclose the injection of hydride material next to the floor of the process chamber as well as next to the ceiling of the process chamber. The beneficial effects of the present invention, as described above, could not have been foreseen based on the disclosure of Saito.

The Examiner stated that it would have been obvious to one of ordinary skill in the art to modify Saito based on the teachings of Kaeppeler to use a hydride. Applicants respectfully disagree.

Kaeppeler does not disclose an MOCVD process but, rather, a CVD process. The starting materials disclosed in Kaeppeler are transported into the process chamber as a hydride and a halide. The hydride is transported through a central line 8 through the gas inlet member and enters the process chamber directly above the floor. The chemical reactions that take place in a MOCVD process are completely different than those that take place in a CVD process as disclosed by Kaeppeler. The CVD process disclosed by Kaeppeler is dominated by reactions in the gas phase. The MOCVD process using metalorganic compounds is characterized by surface reactions. For at

least this reason, a person skilled in the art would never have looked to Kaeppeler to improve a MOCVD process. Thus, Kaeppeler would not have motivated one of ordinary skill in the art to modify the process or device of Saito.

Furthermore, even if one of ordinary skill in the art had been motivated to use a hydride in the device and method of Saito, he or she would not have arrived at the present invention. Saito does not disclose that the gas inlet member is located at the center of the process chamber, nor that the substrates rotate. Even if the device of Saito were modified so that a hydride were introduced via inlet ports 12 and 13, the beneficial effects of the present invention would not be fully realized. The substrate of Saito is not capable of rotation and is not located around a centrally positioned gas inlet member. These aspects of the present invention allow for the beneficial increase in size of the growing zone. For at least this additional reason, the present claims are not obvious.

For the at least the foregoing reasons, Applicants respectfully submit that the claims are patentable over the cited references and are in condition for allowance. Early notice to that effect is earnestly requested.

Respectfully submitted,

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